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Physico-chemical and nutritional properties of kidney beans grown in different regions of Himachal Pradesh

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Abstract
The aim of the present work was to study the physico-chemical and nutritional characterization of six varieties (*Kanchan, Jwala, Baspa, Him1, Triloki* and *Chamba Landrace)* of kidney beans. Pulses are an essential component of our diet especially in developing world, information on their physical properties is needed for designing the machines, while cooking quality is important for consumer acceptance. Physical properties determined the length, and breadth of seeds varied in the range of 8.5–17.80 mm, 4.63-7.63 mm, respectively. The proximate, dietary fiber and anti-nutritional factors of kidney bean varieties grown in Himachal Pradesh were studied. The crude protein in the legumes was in the range of 21.35- 23.58 per cent, crude fat 1.94–2.76 per cent, crude fiber 3.57–4.96 per cent and crude ash 2.99–4.71 per cent. The anti-nutrients, tannin, phytic acid, and trypsin inhibitor were very high in Kanchan, Triloki, and Baspa varieties of Kidney Bean respectively.

Keywords: ADF, celluloses, crude protein, kidney beans, proximate & nutritional properties

1. Introduction
Legumes are an important food source and play a significant role in traditional diets all over the world. Legumes occupy an important place in human nutrition, especially among the people in low-incomes and developing countries (Siddiq *et al*. 2010) [28]. Legumes belongs to the leguminaceae family are produced and consumed widely throughout the world, particularly in tropical and sub tropical areas of Africa, Asia and Latin America (Barampama and Simard,1995) [5]. Red kidney beans (*Phaselous vulgaris*) have greatest popularity in the U.S.A, as well as play long been a part of traditional plant based diet in many cultures of most of the world's developing countries (Shimelis and Rakshit 2007) [27]. Legumes are widely grown and consumed in various regions, are excellent sources of proteins, complex carbohydrates and fairly good sources of minerals, vitamins and polyunsaturated fatty acids (Hudson 1994) [13].
The various types of beans are a staple food and a low-cost source of protein in many countries where protein energy malnutrition is prevalent widely (Van Heerden and Schonfeldt 2004) [30]. High calorie value and easily storable properties of legumes make them all time highly demanding and important part of a human's diet (Singh *et al*. 2004) [29]. Majority of Indian population is vegetarian and legumes are treated as an important economical source of supplementary proteins (Kaur *et al*. 2009) [14]. Legumes generally contain relatively high amount of protein than other plant food stuffs. Kidney bean (*Phaseolus vulgaris*) a grain legume, is one of the neglected tropical legumes that can be used to fortify cereal-based diets especially in developing countries, because of its high protein content (Akobundu *et al*. 1992). Legume proteins are mainly used in food formulations to complement the protein in cereal grains because of their chemical and nutritional characteristics (Enwere 1998) [9]. It is the most important economic variety of the genus *phaselous*. It is an excellent source of vegetable protein, starch, soluble and insoluble fiber, vitamins (especially B group) and minerals (particularly potassium, iron, zinc, magnesium and manganese). They are low in fat (Ekanyake *et al*. 1999).
In Himachal Pradesh Kidney beans are grown in different areas and there are different agro-climatic zones which might affect the nutritional composition of legumes. Much work has not been reported on the physical and nutritional composition of different cultivars of Kidney

beans grown in different districts of Himachal Pradesh. The objective of this study was to determine the physico-chemical properties and nutritional characteristics of red kidney beans.

2. Methods and Materials

Certified seeds of six kidney bean varieties (*Kanchan, Jwala, Baspa, Him 1, Triloki* and *Chamba Landrace*) were procured from Hill Agriculture Research and Extension Centre, Sangla, district Kinnaur region of Himachal Pradesh, India. Seeds were cleaned from the dirt, foreign material etc and stored in dark place for further use. Then, the seeds were grounded in to fine powder with the help of mixer grinder, stored in airtight containers. All the reagents used in the study were of analytical grade. All the analysis was carried out in triplicate.

2.1 Physical characteristics

Physical characteristics observed were color, shape, size. The color and shape of the seeds were observed from their physical appearance through visual perception. One thousand seeds in triplicate from each variety were randomly selected and weighed on an electrical weighing balance. Ten seeds in triplicate were taken and length and breadth was measured with the help of vernier caliper.

2.2. Proximate composition:

The proximate analyses of sample for crude fat, crude fiber and total ash were carried out in triplicate according to the methods of Association of Official Analytical Chemists (AOAC, 2010) [1]. Nitrogen was determined by the micro-Kjeldahl method and was multiplied by the factor of 6.25 for converting it in to crude protein AOAC (2010) [1]. The total carbohydrate content was determined by difference (AOAC 2010) [1]. Total carbohydrates were estimated by (NIN 1983).

2.3 Dietary Fiber Constituents

Dietary fiber constituents include Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), Lignins, Cellulose and Hemicellulose. Neutral detergent Fibre and Acid Detergent Fiber in samples were estimated by the method of Van Soest and Wine (1967) [32]. Lignin content was estimated by the method of Van Soest and Robertson (1985) [30].

Hemicellulose

Hemicellulose was calculated using following formula

Hemicellulose = NDF- ADF

Cellulose

Cellulose was calculated using following formula

Cellulose = ADF – Lignin

2.4 Anti-nutritional factors

The anti-nutritional analyses of sample for Oxalates was estimated by method of (Day and Underwood 1986) [6], Phytic Acid was estimated by method of (Haugh and Lantzch 1983) [11], Tannins was estimated by method of (Makkar *et al*. 1993), Saponin was estimated by the method of (Obadoni and Ochuko 2001) [22] while Trypsin inhibitor was estimated by the method of (NIN, 1983).

3. Results and Discussion

3.1. Physical properties of seeds

Size and shape are an important physical attribute of seeds used in screening solids to separate foreign materials and heat and mass transfer calculations. Table 1 shows the physical characteristics of different Kidney bean varieties. The physical characteristics analyzed were color, shape, length, breadth, L/B ratio, and 100 seed weight. As is clear from data that there was difference in the color and shape of kidney bean varieties procured from different districts Seeds obtained from chamba and kinnaur districts were dark red and ceramic in color with small and large in size. Higher **s**eed weight was observed kidney bean samples procured from Jwala (56.62 g) when compared with other varieties. Minimum seed weight was observed in Chamba Landrace variety (22.35 g). The difference in physical characteristics might have been due to different agro-climatic zones. Modgil *et al.* (2013) analyzed 1000 seed weight and reported the higher 1000 seed weight was in bapsa (540g). Wani *et al*. (2015) [33] reported length, breadth in the range of 11.45- 16.45mm, and 6.65-7.80mm respectively. These differences in seed size may be due to genetic differences (Hu *et al*. 2013) [12]. Length breadth ratio was observed from 1.75 to 2.56 lowest in Him 1 and highest in Baspa.

Table 1: Physical Characteristics of Kidney bean varieties of Himachal Pradesh

Parameter	Varieties						
	Kanchan	**Jwala**	**Baspa**	**Him 1**	**Triloki**	**Chamba Landrace**	**CD ($p \leq 0.05$)**
Color	Dark reddish	Reddish	Light red with white spots	Creamish with brown spots	Creamish	Dark reddish	--
Shape	Large Kidney shaped	Large Kidney shaped	Large Kidney shaped	Medium Kidney shaped	Medium Kidney shaped	Small Kidney shaped	--
Length (mm)	17.80±0.1	17.43±0.06	16.13±0.18	10.53±0.12	10.40±0.1	8.5±0.11	0.41
Breadth (mm)	7.20±0.15	7.63±0.06	6.30±0.17	6.03±0.08	5.86±0.08	4.63±0.08	0.40
L /B ratio	2.47±0.04	2.28±0.01	2.56±0.10	1.75±0.04	1.77±0.03	1.83±0.03	0.18
100 seed weight (g)	40.52±2.8	56.62±1.39	44.53±0.08	29.3±0.29	33.89±0.21	22.35±0.14	3.97

3.2. Nutritional characteristics

3.2.1. Ash

Table 2 shows the ash content is highest in Him 1(4.71 per cent) whereas lowest in Chamba Landrace variety (2.99 per cent). Modgil *et al*. (2013) reported the maximum ash content was present in Himgiri (5.53 per cent) and minimum was in Local Landrace 2 (3.92 per cent). Sasanam *et al*. (2011) [25] evaluated red kidney bean and found that ash content was 3.90 per cent. Parmar *et al*. (2014) [23] evaluated the ash content varied from 2.5per cent to 5.9 per cent. EC501012 and IC342286 showed lower ash content (3 per cent) than EC593020 (5.9per cent). Kaur *et al*. (2009) [14] reported ash content and protein content of 3 to 6 per cent and 16 to 26 per cent, respectively. Fasoyiro *et al*. (2016) [10] reported the ash content of the minor grain legumes was in the range of 3.31–5.64 per cent and lima bean 2 had the highest value.

3.2.2. Fat

It was depicted from Table 2 the fat content is highest in Jwala (2.76 per cent) whereas lowest in Triloki (1.94 per cent). Modgil *et al*. (2013) evaluated significantly highest value in Local Landrace 2 cultivar (4.85 %) and lowest in

Local Landrace 3 cultivar (1.23 %). Fasoyiro *et al*. (2016) [10] reported the minor grain legumes were generally low in fat content which was in the range of 1.91–5.04 per cent. These legumes however contained significantly higher fat than cowpea. Groundnut had the highest fat content of 45.81 per cent.

Table 2: Proximate composition of Kidney bean varieties of Himachal Pradesh

Parameters	Varieties						
	Kanchan	Jwala	Baspa	Him 1	Triloki	Chamba Landrace	CD ($p \leq 0.05$)
Crude protein (%)	22.47±0.27	22.00±0.06	23.58±0.08	21.42±0.4	22.85±0.41	21.35±0.12	0.95
Crude fat (%)	2.16±0.07	2.76±0.07	2.12±0.12	2.04±0.10	1.94±0.08	2.16±0.07	0.31
Crude fiber (%)	3.57±0.11	3.40±0.12	4.65±0.15	4.96±0.05	4.89±0.26	3.57±0.11	0.44
Crude ash (%)	3.33±0.03	4.58±0.13	3.02±0.15	4.71±0.15	3.96±0.26	2.99±0.02	0.52
Total carbohydrate (%)	58.01±0.61	56.12±4.04	54.70±0.54	56.41±0.9	57.43±0.67	60.13±0.22	5.58
Energy (Kcal)	341.36±3.3	337.32±1.6	332.20±1.1	329.68±1.0	338.58±1.6	345.36±0.6	2.83

*Values are on 14 per cent moisture basis

3.2.3. Crude protein
Table 2 depicted the protein content is highest in Baspa (23.58 per cent) whereas lowest in Chamba Landrace (21.35 per cent). The results of present investigation are in accordance with Sai-Ut *et al*. (2010) who investigated red kidney beans, navy beans and adzuki beans and reported that protein content was 17.37, 18.15 and 19.91 per cent respectively. Alonso, *et al*. reported that crude protein in raw kidney seed meals was 23.2 g/100g sample. Kereliuk and Kozub (1994) [15] stated that the protein content of small white (navy) beans was 25.3 g/100g of dry weight. Parmar *et al*. (2014) [23] evaluated the Protein content ranged between 19.25 and 29.93% with the lowest for EC530898 and the highest for EC500974.

3.2.4. Crude fiber
The fiber content was depicted in Table 2 that highest fiber content was found in Him 1 (4.96 per cent) whereas lowest in Chamba Landrace (3.57 per cent). Shimelis and Rakshit (2004) investigated eight improved dry bean varieties and reported a range of crude fiber content between 4.66 to 5.95 g/100g whereas, Adu and Aremu (2011) [4] found that red kidney bean (*Phaseolus vulgaris*) flour contained 3.6 per cent crude fiber. Fasoyiro *et al*. (2016) [10] reported crude fiber contents ranged from 1.98 to 7.22 per cent. African yam bean had the highest crude fiber content of 7.20 per cent while lima bean had the lowest value for this trait.

3.2.5. Total carbohydrate
Table 2 shows total carbohydrate is highest in Chamba Landrace (60.13 per cent) variety whereas lowest in Baspa (54.70 per cent). Adu and Aremu (2011) [4] found carbohydrate content in red kidney bean (*Phaseolus vulgaris*) flour to be 49.0 per cent whereas, Sasanam *et al*. (2011) [25] reported that carbohydrates content in red kidney bean was 60.65 per cent. Fasoyiro *et al*. (2016) [10] was observed that the minor grain legumes had significantly higher carbohydrate contents than soybean and groundnut. The carbohydrate content of soybean and groundnut were 25.19 and 13.74 per cent respectively while those of the other legumes including cowpea ranged between 48.31 and 55.93 per cent.

3.3. Dietary fiber
Table 3 depicted the ADF value is highest in Jwala (7.01 per cent) and lowest in Him1 (4.90 per cent), NDF is highest in Him 1 (13.84 per cent) and lowest in Triloki (10.85 per cent), lignins is highest in Jwala (1.19 per cent) whereas lowest in Triloki (1.02 per cent), celluloses is highest in Jwala (5.79 per cent) and lowest in Him1 (3.81 per cent), whereas hemicelluloses is highest in Him1 (8.93 per cent) and lowest in Kanchan (4.75 per cent).

Table 3: Dietary fiber composition of Kidney bean varieties of Himachal Pradesh

Parameters	Varieties						
	Kanchan	Jwala	Baspa	Him 1	Triloki	Chamba Landrace	CD ($p \leq 0.05$
ADF (%)	6.75±0.04	7.01±0.03	5.05±0.02	4.90±0.05	6.16±0.01	4.95±0.01	0.07
NDF (%)	11.53±0.0	12.90±0.03	11.55±0.5	13.84±0.28	10.85±0.0	12.09±0.03	0.74
Lignins (%)	1.10±0.01	1.19±0.02	1.04±0.02	1.09±0.01	1.02±0.00	1.08±0.01	0.03
Cellulose (%)	5.66±0.03	5.79±0.02	4.00±0.00	3.81±0.04	5.12±0.01	3.86±0.01	0.07
Hemicellulose (%)	4.75±0.05	5.89±0.03	6.00±0.08	8.93±0.33	4.68±0.08	7.13±0.04	0.47

*Values are on 14 per cent moisture basis

3.4. Anti-nutritional composition
3.4.1. Phytic acid
Table 4 shows the phytic acid highest in Triloki (4.40g/100g), lowest in Baspa (3.42g/100g). Fasoyiro *et al*. (2016) [10] reported the phytate content of 5.05 g/100 g. Groundnut had the lowest contents of all anti-nutritional. It was observed that the levels of anti-nutritional factors differed between the two collections of the same minor legume species investigated.

3.4.2. Saponins
Table 4 shows the saponins highest in Kanchan (3209.60 mg/100g), lowest in Baspa (1099.63 mg/100g). Khokhar *et al*. (1986) evaluated moth bean was found to be a fairly rich source of saponin and the concentration among cultivars varied significantly from 2833 to 3349 mg/l00g on dry matter basis.

3.4.3. Tannins
Table 4 shows the tannins highest in Kanchan (4.91 mg/100g), lowest in Triloki (3.66 mg/100g). Fasoyiro *et al*. (2016) [10] reported the tannin content of the minor grain legumes were significantly higher than those recorded for the major grain legumes. Tannin contents among the minor grain legumes were in the range of 4.60–8.99 g/100 g. African yam

bean 2 had the highest tannin content of 8.99 g/100 g. For instance, lima bean 1 (white seeded) had significantly higher tannin content (7.89 g/100 g) than lima bean 2 (colored seed) with tannin content of 5.05 g/ 100 g. Kaur *et al*. (2016) examined the average amount of tannin was found to be 6.45 mg g-1 in chickpea genotypes. The highest amount of tannin was observed in GL 28008 (8.43 mg g-1) and lowest in ICCV 96030 (5.25 mg g-1). Tannins are resistant to degradation, so are likely to remain in the digestive tract and not being absorbed and transported to other tissues.

Table 4: Anti-nutritional composition of Kidney bean varieties of Himachal Pradesh

Parameter	Varieties						
	Kanchan	Jwala	Baspa	Him 1	Triloki	Chamba Landrace	CD (p≤0.05)
Saponins (mg/100g)	3209.60±7.22	2999.84±7.43	1099.63±3.87	1486.22±10.02	2164.07±14.39	1416.72±1.52	27.82
Tannins (mg/100g)	4.91±0.01	4.19±0.01	4.23±0.01	3.90±0.03	3.66±0.02	3.88±0.00	0.10
Oxalates (mg/100g)	16.13±0.08	16.7±0.11	16.56±0.08	15.93±0.03	16.73±0.16	16.73±0.12	0.37
Phytic acid (g/100g)	3.98±0.01	3.99±0.00	3.42±0.23	3.87±0.05	4.40±0.09	3.87±0.01	0.34
Tyrpsin inhibitor (TIU/mg)	114.00±1.15	110.00±0.57	116.66±0.66	117.33±0.33	118.67±0.33	118±0.57	1.95

*Values are on 14 per cent moisture basis

3.4.4. Trypsin inhibitor

Table 4 shows the tyrpsin inhibitor highest in Triloki (118.67 TIU/mg), lowest in Jwala (110.00 TIU/mg). Fasoyiro *et al*. (2016) [10] reported the pigeon pea 2 had the highest trypsin inhibitor value of 30.27 Tiu/mg. Groundnut had the lowest contents of all anti-nutritional.

Different varieties of Kidney Beans

4. Conclusion

From the present study it can be concluded that physical characteristics like length was highest in Kanchan whereas breadth was highest in Jwala. 1000 seed weight was highest in Jwala of kidney beans as compared with other varieties. Kidney beans grown in different agro-climatic zones have difference in their physical characteristics. Protein content is high in Baspa variety and low in Him 1 variety. It is clear now that kidney bean could substantially improve the nutritional needs of a population. Both urban and rural populations, especially the low income groups would benefit from nutrient potentials of kidney bean, particularly at times of seasonal scarcity of staple crops. The anti-nutrients, tannin, phytic acid, and trypsin inhibitor were very high in Kanchan, Triloki, and Baspa varieties of Kidney Bean respectively.

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6. Reference

1. AOAC, Official Methods of Analysis, 17thedn. Association of Official Analytical Chemists, Washington, D.C., U.S.A, 2010
2. Akobundu ENT, Hoskins FH. Potential of corn-cowpea mixture as infant food, Journal of Food and Agriculture 1987; 2:111-114.
3. Alonso R, Rubio LA, Muzquiz M, Marzo F, The effect of extrusion cooking on mineral bioavailability in pea and kidney bean seed meals, Animal Feed Science and Technology. 2001; 94:1-13
4. Audu SS, Aremu MO. Effect of processing on chemical composition of red kidney (*Phaseolus vulgaris* L.) flour, Pakistan Journal of Nutrition. 2011; 10:1069-1075.
5. Barampama S, Simard RE. Effect of soaking, cooking and fermentation on composition, *in vitro* starch digestibility and nutritive value of common beans, Plant Foods for Human Nutrition. 1995; 40:349-365.
6. Day RA, Underwood AL. Qualitative Analysis.5th Ed. New Delhi, India: Prentice Hall Publications, 1986, 701.
7. Dhaliwal YS, Verma R, Mittal RK, Bhandari DC. Buckwheat, ricebean and amaranthus-value added products, Booklet published under AICRN project on underutilized crops, 2011.
8. Eknayake S, Jansz ER, Nasir BM. Proximate Composition, mineral and amino acid content of nature (*Canavalla gladiate* seed), Food Chem. 1999; 66:119.
9. Enwere NJ. Foods of Plant Origin, Afro-Obis Publications Ltd., Nsukka, 1998, 43-46.
10. Fasoyiro SB, Ajibade SR, Omole AJ, Adeniyan ON, Farinde EO. Proximate, minerals and anti-nutritional factors of some underutilized grain legumes in south-western Nigeria, Nutrition & Food Science. 2016; 36:18-23.
11. Haugh W, Lantzch HJ. Sensitive method for the rapid determination of phytates in cereals and cereal products, Journal of the Science of Food and Agriculture. 1983; 34:1423-1427.
12. Hu Z, Zhang H, Kan G, Ma D, Zhang D, Shi G *et al*. Determination of the genetic architecture of seed size and shape via linkage and association analysis in soybean (*Glycine max* L. Merr.), Genetica, 2013; 141(4, 6):247-254.
13. Hudson BJF, New and Developing source of food proteins, Chapman & Hall, London, 1994.
14. Kaur S, Singh N, Sodhi NS, Rana JC. Diversity in properties of seed and flour of kidney bean germplasm, Food Chemistry. 2009; 117:282-289.

15. Kereliuk GR, Kozub GC. Chemical composition of small white (navy) beans, Academic Press Limited, 1994; 28:272-278.
16. Khokhar S, Chauhan BM. Antinutritional Factors in Moth Bean (*Vigna aconitifolia*): Varietal Differences and Effects of Methods of Domestic Processing and Cooking, Journal of Food Science. 1986; 51:591.
17. Malhotra SR, Bhama S, Sharma A. Standardization and chemical composition of traditional recipes prepared from legumes and pulses, 2008.
18. Malhotra SR, Sharma A, Bhama S. Nutritional evaluation of legume based preparations commonly consumed in H.P, Himachal Journal of Agricultural Research. 2005; 31(1):110-114.
19. Mankotia K, Modgil R. Effect of Soaking Sprouting and Cooking on Physico- Chemical Properties of Moth Beans (*Vigna acontifolia*), J Human Ecology. 2003; 14(4):297-299.
20. Mankotia K, Modgil R. Effect of Soaking Sprouting and Cooking on Physico- Chemical Properties of Kidney Beans, Legume research, 2004.
21. Makkar HPS, Blummel M, Borowy NK, Becker K. Gravimetric determination of tannins and their correlation with chemical and protein precipitating method, Journal of the Science of Food and Agriculture. 1993; 61:161-165.
22. Obadoni BO, Ochuko PO. Phyto-chemical studies and comparative efficacy of the crude extracts of some homeostatic plants in Edo and Delta States of Nigeria, Global Journal of Pure and Applied Science. 2001; 8:203-208.
23. Parmar N, Virdi AS, Singh N, Kaur A, Bajaj R, Rana JC, *et al*. Evaluation of physicochemical, textural, mineral and protein characteristics of kidney bean grown at Himalayan region, Food Research International. 2014; 66:45-57.
24. Sai-Ut S, Ketnawa S, Chaiwut P, Rawdkuen S. Biochemical and functional properties of red kidney, navy and adzuki beans, Journal of Agro Food Industry. 2009; 2:493-504.
25. Sasanam S, Paseephol T, Moongngarm A. Comparison of proximate compositions, resistant starch content and pasting properties of different colored cowpeas (*Vigna unguiculata*) and red kidney bean (*Phaseolus vulgaris*), World Academy of Science, Engineering and Technology. 2011; 81:315.
26. Sharma S, Food consumption pattern and nutritional enrichment of commonly consumed recipes of Chamba and Kangra region of Himachal Pradesh. (Msc Thesis, CSKHPKV, Palampur, India), 2005.
27. Shimelis EA, Rakshit SK. Effect of processing on anti-nutritional and *in vitro* protein digestibility of kidney bean (*Phaseolus vulgaris* L.) varieties grown in East Africa, *Food chemistry*, 2007; 103:161- 172.
28. Siddiq M, Ravi R, Harte JB, Dolan KD. Physical and functional characteristics of selected dry bean (*Phaseolus vulgaris* L.) flours, LWT – Food Science and Technology. 2010; 43(2):232-237.
29. Singh N, Kaur M, Sandhu KS, Sodhi NS. Physicochemical, cooking and textural characteristics of some Indian black gram varieties (*Phaseolus mungo* L.), Journal of the Science of Food and Agriculture. 2004; 84:977-982.
30. Van Heerden SM, Schonfeldt HC. The need for food composition tables for Southern Africa, Journal of Food Composition and Analysis. 2004; 17:531-537.
31. Van Soest PJ, Robertson JB. Analysis of Forages and Fibrous Foods, laboratory manual for animal science, Cornell University Press, 1985, 202.
32. Van Soest PJ, Wine RH. Use of detergent in the analysis of fibrous foods, determination of plant cell wall constituents, Journal of Association of Official Analytical Chemistry, 1967; 50:50.
33. Wani IA, Sogi DS, Wani AA, Gill BS. Physical and cooking characteristics of some Indian kidney bean (*Phaseolus vulgaris* L.) cultivars, Journal of the Saudi Society of Agricultural Sciences, 2015.